



Search for Excited and Exotic Leptons

Sharon Hagopian

Florida State University

On behalf of the CDF and DØ Collaborations



Outline



Introduction

DØ Search for Excited Electrons

CDF Search for Excited and Exotic Muons

DØ Search for Excited Muons

Summary



Search for Excited Leptons

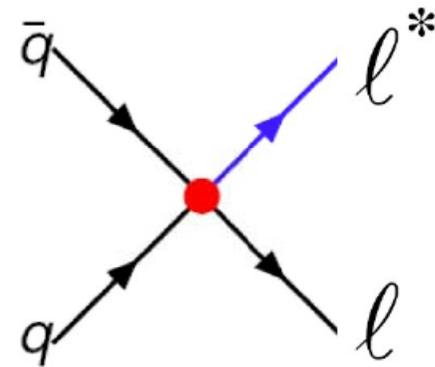


A proposed explanation for 3 generations of quarks and leptons is that they are composed of scalar and spin-1/2 particles, leading to a spectrum of excited states

$$e^*, \mu^*, q^*$$

Their production can be described by contact interactions (CI) between quarks and leptons.

Excited lepton production by CI at the Tevatron is parameterized by the mass of the excited lepton, m_{l^*} , and the compositeness scale, Λ .





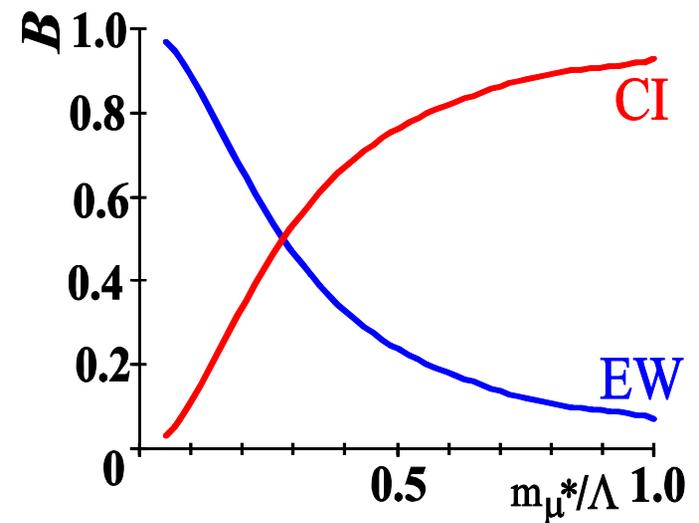
Search for Excited Leptons



Decay can be via electroweak interactions or via contact interactions (model dependent).

DØ uses a model proposed by Baur, Spira and Zerwas which has CI interaction decays, while CDF considers only EW decays.

Both experiments analyze final states with one radiated photon -very small background.



Ref: U.Baur, M. Spira and P.M. Zerwas
Phys. Rev. D **42**, 815 (1990)

Note: assumes $f = f' = 1$
CI decays lead to
3 fermion states



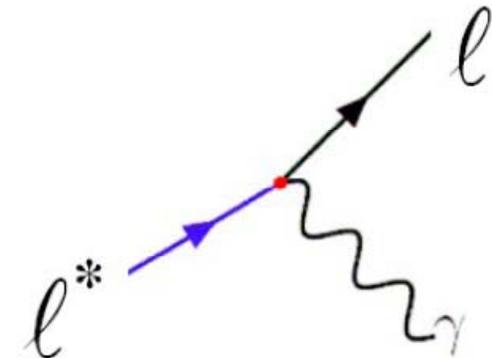
Search for Exotic Leptons



Exotic fermions are also predicted in extensions of the SM motivated by GUTs or string theory and would be produced via gauge interactions - called gauge-mediated models (GM).

Production is parameterized by the mass of the exotic lepton, m_{l^*} , and the ratio f/Λ , where f is a phenomenological constant.

Search for exotic and excited leptons in $l l^*$ associated production followed by the radiative decay $l^* \rightarrow l \gamma$





Past Searches



LEP experiments used direct searches for e^* produced via gauge interactions.

For $e^+ e^- \rightarrow e e^*$, set limits up to $m_{e^*} > 200$ GeV

Similar limits for m_{μ^*} limited by Center of Mass energy.

HERA I experiments searching for $e p \rightarrow e^* X$ set limits up to $m_{e^*} > 250$ GeV (See update in next talk)

CDF searched for GM production of e^* in early Run 2 analysis using 200 pb^{-1} of data to set limits up to $m_{e^*} > 420$ GeV.

Also explored interpreting their results in term of compositeness models with contact interactions.

DØ Search for e^*

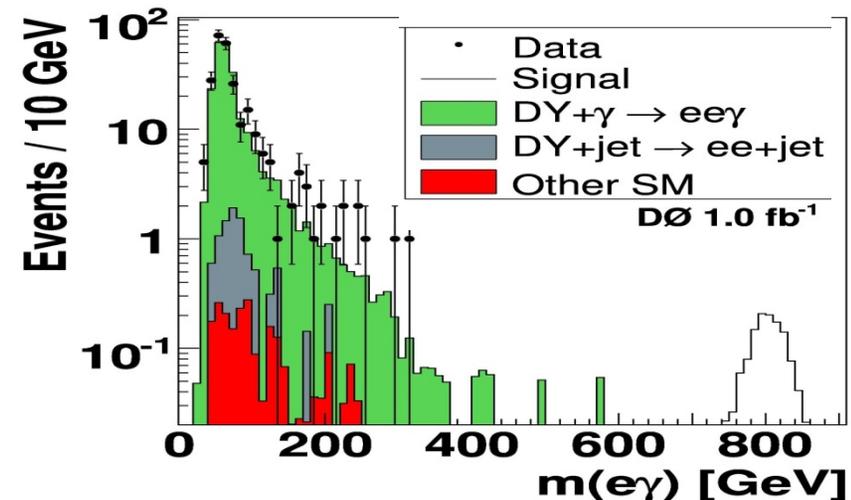
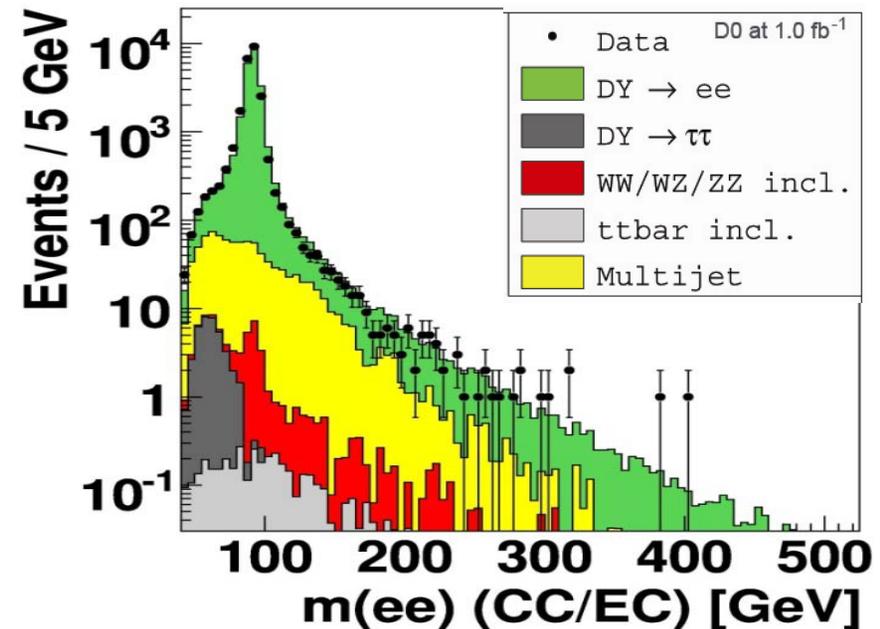


Initial Selection (1.0 fb^{-1})
 2 isolated electrons with
 $E_T > 25 \text{ GeV}$, $E_T > 15 \text{ GeV}$
 1 isolated photon with
 $E_T > 15 \text{ GeV}$

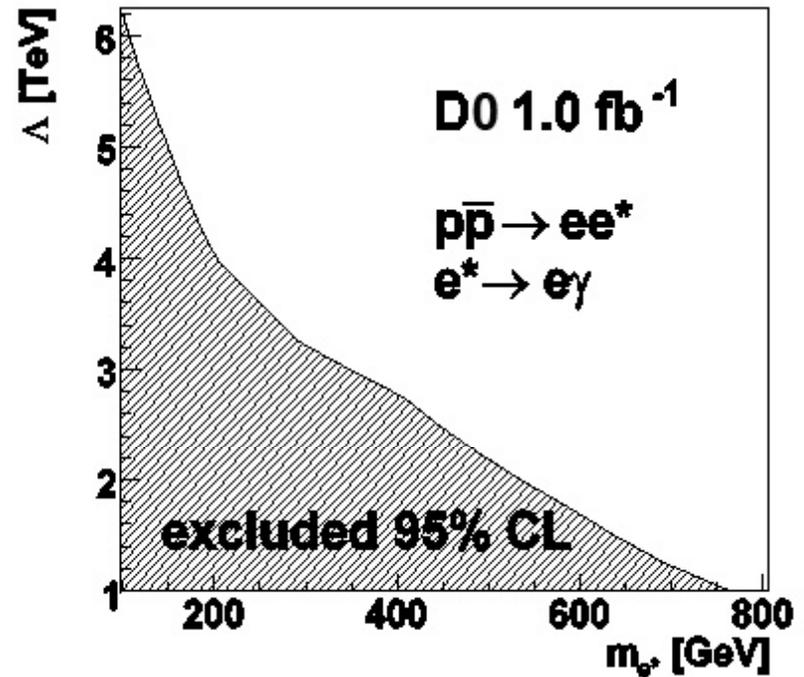
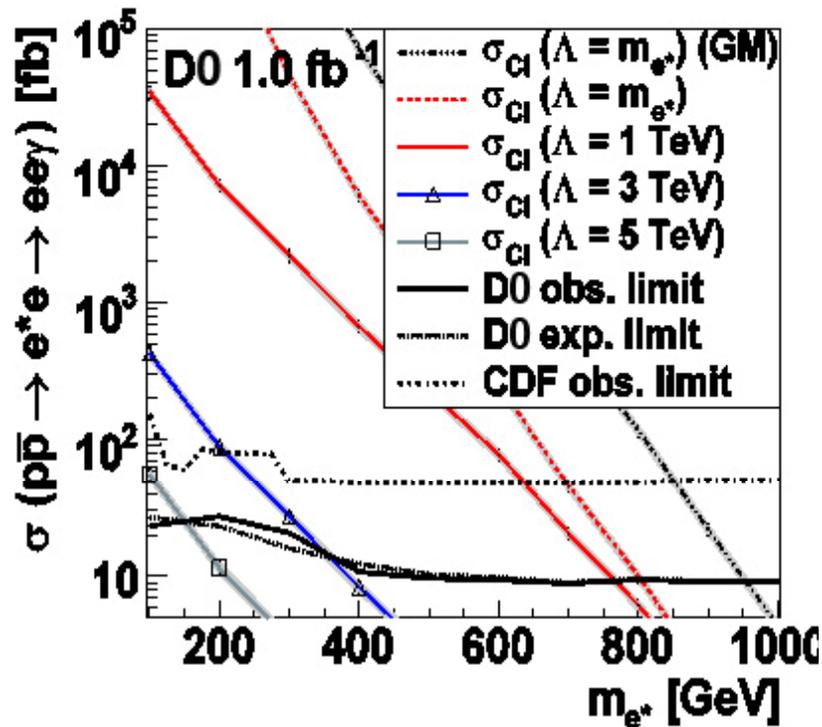
Data : 259 events
 Background 232 ± 36 events
 Background dominated by
 $DY + \gamma \rightarrow ee\gamma$

Search for a peak in $m_{e\gamma}$

Plot shows expected signal if
 $m_{e^*} = 800 \text{ GeV}$, $\Lambda = 1 \text{ TeV}$



DØ Search for e^*



DØ limits at 95% CL

$m_{e^*} > 756 \text{ GeV}$ for $\Lambda = 1 \text{ TeV}$

$m_{e^*} > 946 \text{ GeV}$ for $\Lambda = m_{e^*}$ (no CI decays)

Accepted for publication in PRD Rapid Communications

Fermilab-Pub-08-007-E; arXiv:0801.0877



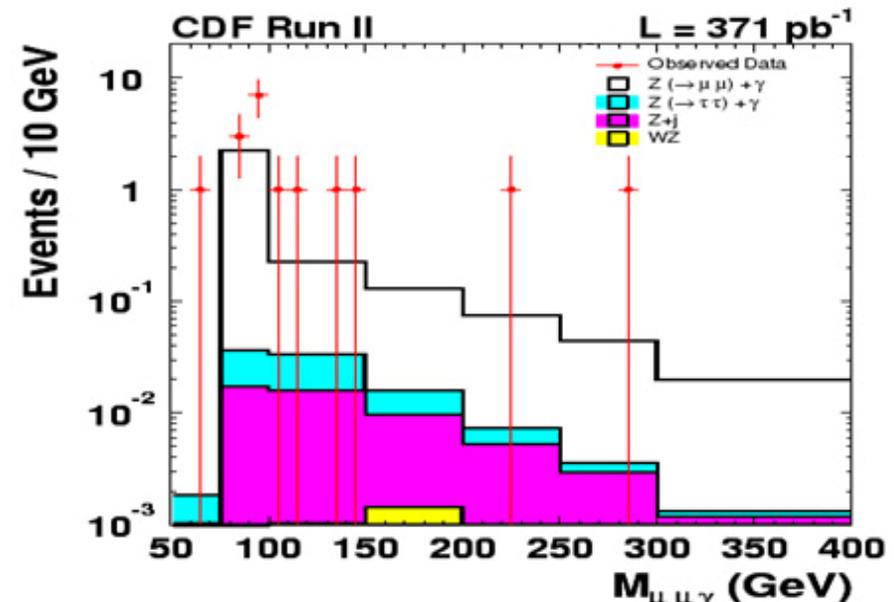
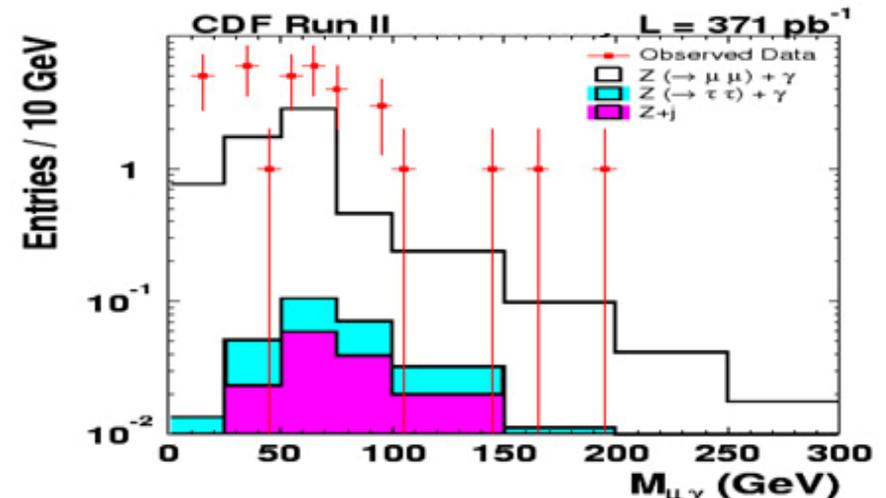
CDF Search for Excited and Exotic muons

Selection (370 pb^{-1})
2 isolated muons both with
 $E_T > 20 \text{ GeV}$
1 isolated photon with
 $E_T > 25 \text{ GeV}$

Data : 17 events

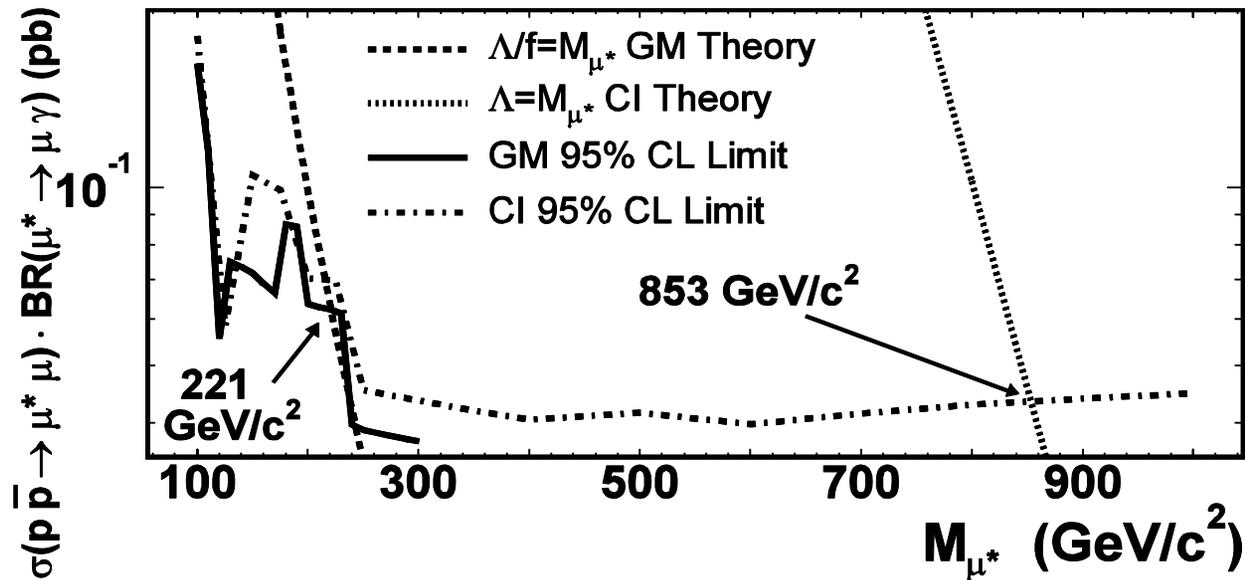
Background 8.3 ± 0.9 events

Dominant background $Z\gamma$
Data excess predominantly
in the $Z \rightarrow \mu\mu\gamma$ FSR region
(11 candidate events,
5.5 events predicted)





CDF Search for Excited and Exotic muons



Cross section x branching ratio vs m_{μ^*}

CDF limits at 95% CL

$m_{\mu^*} > 221 \text{ GeV}$ for $\Lambda/f = m_{\mu^*}$ (GM model)

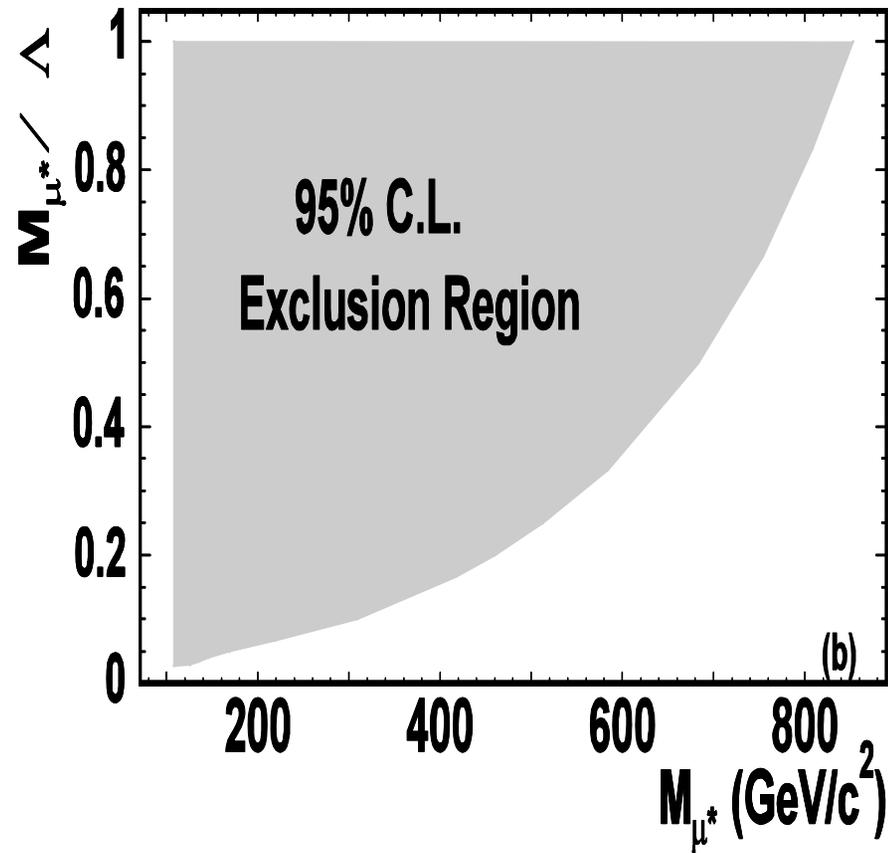
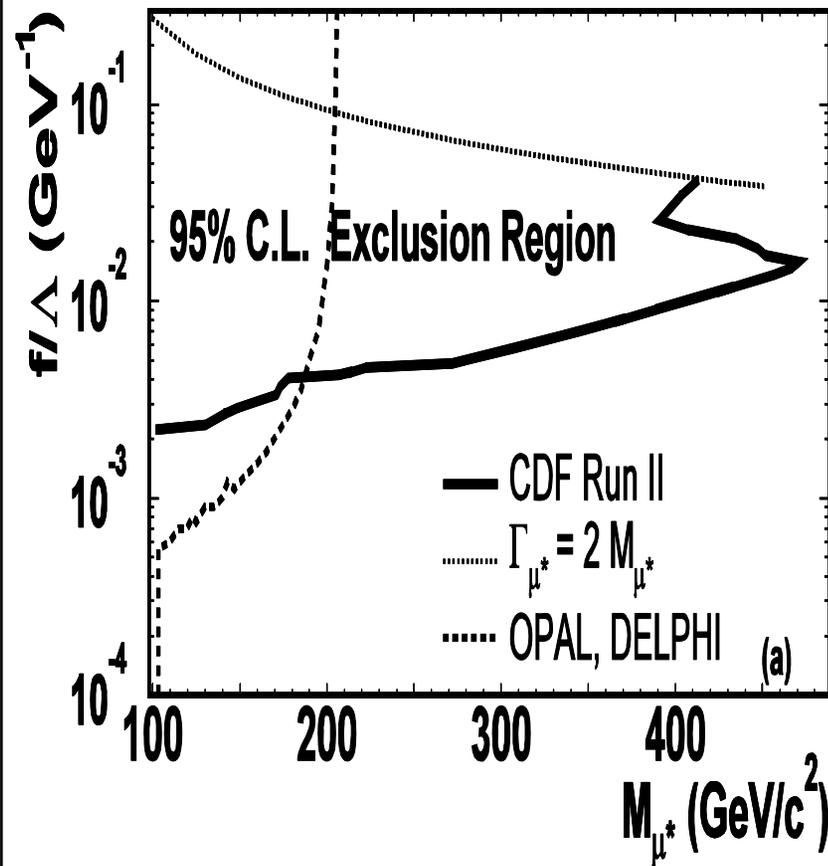
$m_{\mu^*} > 410 \text{ GeV}$ for $f/\Lambda = 10^{-2} \text{ GeV}^{-1}$ (GM model)

$m_{\mu^*} > 853 \text{ GeV}$ for $\Lambda = m_{\mu^*}$ (CI model; no CI decays)

Note: $m_{\mu^*} > 696 \text{ GeV}$ for $\Lambda = m_{\mu^*}$ (CI; including CI decays)



CDF Search for Excited and Exotic muons



2-D exclusion regions for GM and CI models

Published in PRL **97**, 191802 (2006)

DØ Search for μ^*



Selection (380 pb^{-1})

2 muons : $p_T > 15 \text{ GeV}$

(at least 1 isolated muon)

1 isolated photon with

$E_T > 16 \text{ GeV}$

Data : 90 events

Background 65 ± 40 events

dominant background $Z\gamma$

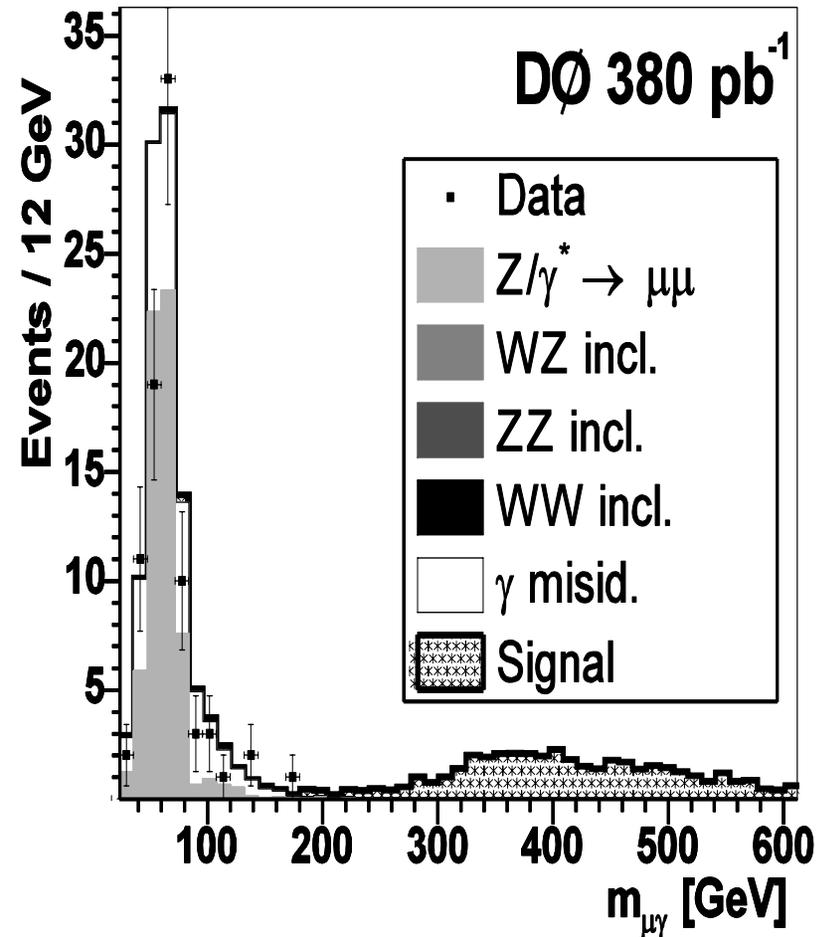
uncertainty due to fake γ

negligible for high m_{μ^*}

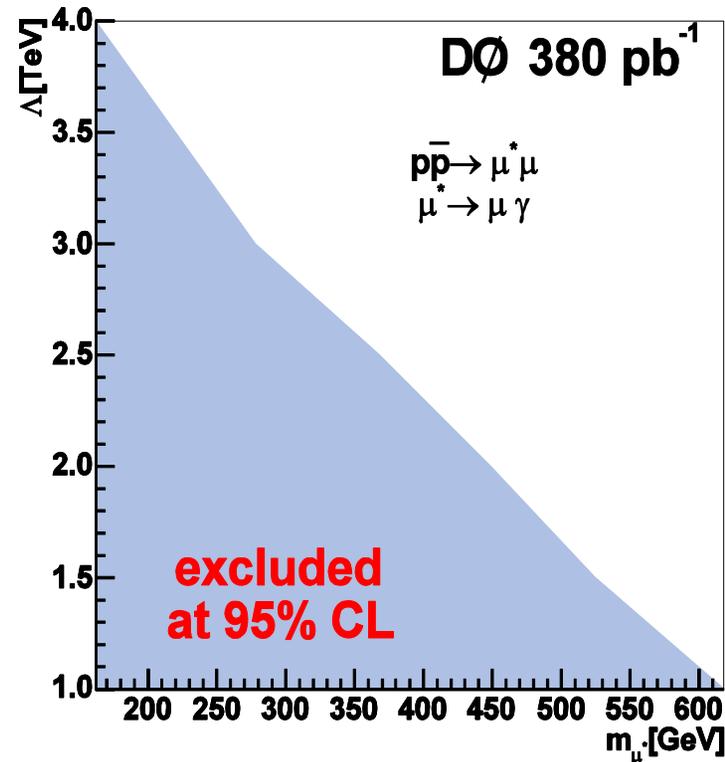
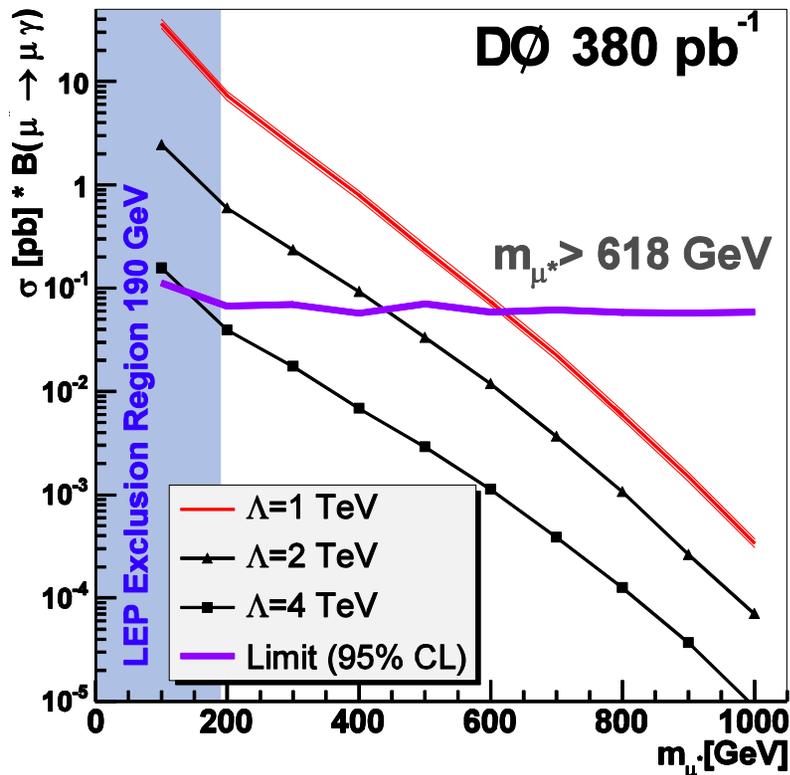
Plot of $m_{\mu\gamma}$ for leading muon

and expected signal for

$m_{\mu^*} = 400 \text{ GeV}$ and $\Lambda = 1 \text{ TeV}$



DØ Search for μ^*



Cross section x branching ratio vs m_{μ^*} 2 D exclusion plot
 $m_{\mu^*} > 618$ GeV for $\Lambda = 1$ ($m_{\mu^*} > 890$ GeV for $\Lambda = m_{\mu^*}$)
 Published in PRD 73, 111102(R) (2006)



Conclusions



- CDF and D0 have performed searches for excited and exotic leptons
- No evidence for such leptons has been found so far
- Check Web sites for details and new information:

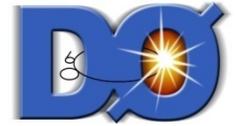
CDF – <http://www-cdf.fnal.gov/physics/exotic/exotic.html>

D0 <http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm>

Keep posted for new results

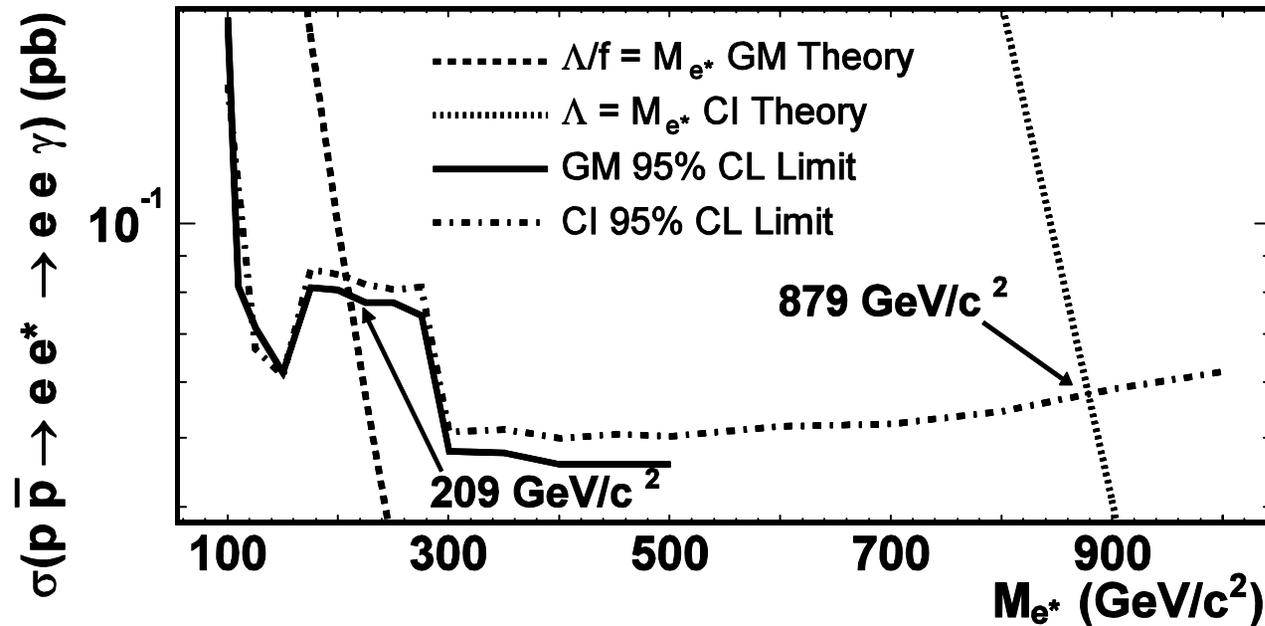


Back-up





CDF Search for e^*



$m_{e^*} > 879 \text{ GeV}$ for $\Lambda = m_{e^*}$ (no CI decays)

Note: $D\bar{0} m_{e^*} > 946 \text{ GeV}$ for $\Lambda = m_{e^*}$ (no CI decays)

Published in PRL **94**, 101802 (2005)



Limits on Compositeness Scale Λ



Searches for quark-lepton compositeness via deviations from DY cross section at the Tevatron set limits on Λ up to 6 TeV depending on the chirality.

Most stringent limits are from atomic parity violation experiments.

Search in exclusive channels $\ell\ell\gamma$ are complementary and consider different couplings (η factors)